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Turbulent Molecular Processes and Structures in Supersonic Free Shear Layers

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Summary of all Work Accomplished

We proposed to begin to use our unique Ludwieg tube-wind-tunnel in order to determine Reynolds number and Mach number effects on the dynamics of coherent structures in a supersonic free shear layer. We proposed to implement fluorescence in NO_2 as a local point density diagnostic and to develop a capacity of simultaneous three dimensional measurements of velocity and Reynolds number histories in the free shear layer and to determine as well the axial and transverse profiles for such a flow. Further, using a variety of standard and novel analytical tools, we proposed to begin to determine the controlling dynamical underpinnings of supersonic transport phenomena. All of these objectives have been achieved.

Using a Mach number 2.5 nozzle, we have confirmed our previously published evidence of Reynolds number sensitivity in supersonic turbulent shocklets in compressible free shear layers[1]. We have determined that shocklet-producing entities are low velocity systems in these flows and have impact on the local scales associated with turbulent effects[2]. We have determined a local evolution of coherence in the Reynolds stress data, using both phase coherence velocimetry and new techniques for direct velocity estimations, between the on-axis and off-axis regions of the free shear layer[3]. We find that classical turbulent effects are in a long-wavelength range while effects accompanying chaos are at short wavelengths,- with fractal dimensions which suggest that the observed chaotic behavior evolves from instabilities in flow which is topologically two dimensional. We have begun to determine the role which turbulent shocklets might play in these phenomena. We have also successfully applied these theoretical concepts to Reynolds stress measurements in a turbulent ionizing shock wave as an emulator of free shear layer flow[4].

In results not yet published, we have begun to determine precisely the chaotic signatures for supersonic turbulent shocklets. We are using the direct velocity estimator techniques for velocity measurements in the supersonic turbulent free shear layer and are beginning to compare our results with some of the popular models. We have begun to use phase coherence velocimetry to determine the degree of coherence intermittency in the supersonic turbulent free shear layer. We will measure the influence of a change in the local Mach number on our results and, with this, contribute to a phenomenological enhancement to the Navier Stokes equations.

References

1. "Evidence of Reynolds Number Sensitivity in Supersonic Turbulent Shocklets," AIAA Journal, 26, 502 (1988). (With L. E. Johnson and Y. Zhang.)

2. "Preliminary Data on the Dynamics of Turbulent Shocklets," International Conference on the Physics of Compressible Turbulent Flow, 1991 (to be published). (With L. E. Johnson, J. Zhang and Y. Zhang.)

3. "Direct Reynolds Stress Measurements using High Energy Density Turbulent Velocimetry in Supersonic Free Shear Layers," Bull. Am.Phys. Soc., 35, 2326 (1990). (With L. E. Johnson and J. Zhang.)

4. "Chaotic Processes in Magnetized Turbulent Shock Waves," 18th International Symposium on Shock Waves, (K. Takayama, ed.) July 21-26 1991, Sendai, Japan (Berlin; Springer-Verlag) (to be published). (With L. E. Johnson and Z. Liang.)

Index of All Technical Reports and Publications

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